

Physical Activity and Health

Table 2-2. *Continued*

Source	Objective	Type/mode
AHA Position Statement (1993)	CVD prevention and rehabilitation	Moderate intensity (i.e., brisk walking) integrated into daily routine
ACSM Position Stand (1994)	Secondary prevention in patients with coronary heart disease	Endurance, strength
AHA Position Statement (1994)	Cardiac rehabilitation	Endurance and strength training of moderate intensity following other guidelines
Physical Activity Guidelines for Adolescents (1994) [†]	Lifetime health promotion for adolescents	Endurance
AACVPR (1995)	Cardiac rehabilitation	Endurance, strength
ACSM Guidelines (1995)	Cardiorespiratory fitness and muscular fitness	Endurance, strength
ACSM Position Stand (1995)	Prevention of osteoporosis	Strength, flexibility, coordination, cardiorespiratory fitness
AHCPR (1995)	Cardiac rehabilitation	Endurance, strength
AMA Guidelines for Adolescent Preventive Services (GAPS) (1994)	Health promotion/physical fitness	Endurance
CDC/ACSM (1995) [†]	Health promotion	Endurance
USHHS/USDA Dietary Guidelines (1995)	Health promotion/disease prevention, weight maintenance	Endurance
NHLBI Consensus Conference (1996)	CVD prevention for adults and children and cardiac rehabilitation	Endurance
USPSTF (1996)	Primary prevention in clinical practice	Endurance, strength, flexibility

Historical Background, Terminology, Evolution of Recommendations, and Measurement

Intensity	Endurance		Resistance training
	Frequency	Duration	
Not specified	Not specified	Not specified	Not addressed
40–85% $\dot{V}O_2$ max 40–85% HRR 55–90% MHR	3 x week, nonconsecutive days	20–40 minutes	Not specified
Not specified	Not specified	Not specified	Not specified
Moderate/vigorous	3 x week, vigorous daily, moderate	≥ 20 minutes, vigorous not specified, moderate	Not addressed
> 50% $\dot{V}O_2$ max RPE 12–14	3–5 x week	30–45 minutes, 200–300 kcal per session or 1,000–1,500 kcal per week	1 set, 10–15 repetitions, major muscle groups 2–3 days x week
40–85% $\dot{V}O_2$ max/HRR RPE 12–16	3–5 x week	12–15 minutes initially: 20–30 minutes for conditioning and maintaining	1 set, 8–12 repetitions 8–10 exercises 2 days x week
Not specified	Not specified	Not specified	Not specified
70–85% MHR	3 x week	20–40 minutes	Not specified
Moderate	≥ 3 x week	20–30 minutes	Not addressed
Moderate/hard	All or most days	≥ 30 minutes per day in bouts of at least 8–10 minutes	Not specified
Moderate	All or most days	≥ 30 minutes per day	Not addressed
Moderate/hard	All or most days	≥ 30 minutes per day	Not addressed
Moderate	Most days	30 minutes	Not specified

*See Appendix B for listing of objectives. †See Sallis and Patrick, 1994. *See Pate et al., 1995.

Key to associations: AACVPR = American Association for Cardiovascular and Pulmonary Rehabilitation; ACSM = American College of Sports Medicine; AHA = American Heart Association; AHCPR = Agency for Health Care Policy and Research; CDC = Centers for Disease Control and Prevention; NHLBI = National Heart, Lung, and Blood Institute; PCPF = President's Council on Physical Fitness; USDA = United States Department of Agriculture; USDHEW = United States Department of Health, Education, and Welfare; USDHHS = United States Department of Health and Human Services; USPSTF = United States Preventive Services Task Force; YMCA = Young Men's Christian Association.

Key to abbreviations: CHD = coronary heart disease; CVD = cardiovascular disease; HRR = heart rate reserve; MHR = maximal heart rate; RPE = rating of perceived exertion; $\dot{V}O_2$ max = maximal oxygen uptake.

Not addressed = not included in recommendations. Not specified = recommended but not quantified.

Physical Activity and Health

all children and adults to accumulate at least 30 minutes per day of moderate-intensity physical activity. The recommendations also acknowledge that persons already achieving this minimum could experience greater benefits by increasing either the duration or the intensity of activity. In addition, the statement recommends more widespread use of cardiac rehabilitation programs that include physical activity.

The consensus statement from the 1993 International Consensus Conference on Physical Activity Guidelines for Adolescents (Sallis and Patrick 1994) emphasizes that adolescents should be physically active every day as part of general lifestyle activities and that they should engage in 3 or more 20-minute sessions of moderate to vigorous exercise each week. The American Academy of Pediatrics has issued several statements encouraging active play in preschool children, assessment of children's activity levels, and evaluation of physical fitness (1992, 1994). Both the consensus statement and the American Academy of Pediatrics' statements emphasize active play, parental involvement, and generally active lifestyles rather than specific vigorous exercise training. They also acknowledge the need for appropriate school physical education curricula.

Recognizing the important interrelationship of nutrition and physical activity in achieving a balance between energy consumed and energy expended, the 1988 Surgeon General's Report on Nutrition and Health (USDHHS 1988) recommended physical activities such as walking, jogging, and bicycling for at least 20 minutes, 3 times per week. The 1995 *Dietary Guidelines for Americans* greatly expanded physical activity guidance to maintain and improve weight. The bulletin recommends that all Americans engage in 30 minutes of moderate-intensity physical activity on all, or most, days of the week (USDA/USDHHS 1995).

The U.S. Preventive Services Task Force (USPSTF) has recommended that health care providers counsel all patients on the importance of incorporating physical activities into their daily routines to prevent coronary heart disease, hypertension, obesity, and diabetes (Harris et al. 1989; USPSTF 1989, 1996). Similarly, the American

Medical Association's *Guidelines for Adolescent Preventive Services* (GAPS) (AMA 1994) recommends that physicians provide annual physical activity counseling to all adolescents.

Summary of Recent Physical Activity Recommendations

Sedentary persons can increase their physical activity in many ways. The traditional, structured approach originally described by the ACSM and others involved rather specific recommendations regarding type, frequency, intensity, and duration of activity. Recommended activities typically included fast walking, running, cycling, swimming, or aerobics classes. More recently, physical activity recommendations have adopted a lifestyle approach to increasing activity (Pate et al. 1995). This method involves common activities, such as brisk walking, climbing stairs (rather than taking the elevator), doing more house and yard work, and engaging in active recreational pursuits. Recent physical activity recommendations thus acknowledge both the structured and lifestyle approaches to increasing physical activity. Either approach can be beneficial for a sedentary person, and individual interests and opportunities should determine which is used. The most recent recommendations cited agree on several points:

- All people over the age of 2 years should accumulate at least 30 minutes of endurance-type physical activity, of at least moderate intensity, on most—preferably all—days of the week.
- Additional health and functional benefits of physical activity can be achieved by adding more time in moderate-intensity activity, or by substituting more vigorous activity.
- Persons with symptomatic CVD, diabetes, or other chronic health problems who would like to increase their physical activity should be evaluated by a physician and provided an exercise program appropriate for their clinical status.

Historical Background, Terminology, Evolution of Recommendations, and Measurement

- Previously inactive men over age 40, women over age 50, and people at high risk for CVD should first consult a physician before embarking on a program of vigorous physical activity to which they are unaccustomed.
- Strength-developing activities (resistance training) should be performed at least twice per week. At least 8–10 strength-developing exercises that use the major muscle groups of the legs, trunk, arms, and shoulders should be performed at each session, with one or two sets of 8–12 repetitions of each exercise.

Measurement of Physical Activity, Fitness, and Intensity

The ability to relate physical activity to health depends on accurate, precise, and reproducible measures (Wilson et al. 1986; National Center for Health Statistics 1989). Measurement techniques have evolved considerably over the years (Park 1989), creating a shifting pattern of strength and weakness in the evidence supporting the assertion that physical activity improves health (Ainsworth et al. 1994). The complexity is heightened by the different health implications of measuring activity, gauging intensity, and assessing fitness. The tools currently in use (Table 2-3) must be evaluated not only for their efficacy in measuring an individual's status, but also for their applicability as instruments in larger-scale epidemiologic research. These tools vary considerably in the age groups to which they can be applied, as well as in their cost, in their likelihood of affecting the behavior they try to measure, and in their acceptability. For example, many of the tools that are appropriate for young and middle-aged persons are less so for the elderly and may have no relevance at all for children. A brief review of these approaches provides some insight into the current constellation of strengths and weaknesses on which epidemiologic conclusions rest.

Measuring Physical Activity

Measures Based on Self-Report

Physical activity is a complex set of behaviors most commonly assessed in epidemiologic studies by asking people to classify their level of physical activity

(LaPorte, Montoye, Caspersen 1985; Caspersen 1989). Techniques used to gather this self-reported information include diaries, logs, recall surveys, retrospective quantitative histories, and global self-reports (Kannel, Wilson, Blair 1985; Wilson et al. 1986; Powell et al. 1987; Caspersen 1989). Surveys are practical for assessing physical activity in large populations because they are not costly, are relatively easy to administer, and are generally acceptable to study participants (Montoye and Taylor 1984; LaPorte, Montoye, Caspersen 1985; Caspersen 1989). Information obtained from self-report instruments has often been converted into estimates of energy expenditure (i.e., kilocalories or kilojoules; metabolic equivalents [METs]) or some other summary measure that can be used to categorize or rank persons by their physical activity level. This technique has also been used to convert job classifications into summary measures.

Diaries can detail virtually all physical activity performed during a specified (usually short) period. A summary index can be derived from a diary by 1) summing the total duration of time spent in a given activity multiplied by an estimated rate of energy expenditure for that activity, or 2) listing accumulated time across all activities or time accrued within specific classes of activities. Comparisons with indirect calorimetry or with caloric intake have shown that diaries are accurate indices of daily energy expenditure (Acheson et al. 1980). Because diaries are commonly limited to spans of 1–3 days, they may not represent long-term physical activity patterns (LaPorte, Montoye, Caspersen 1985). Diaries require intensive effort by the participant, and their use may itself produce changes in the physical activities the participant does during the monitoring period (LaPorte, Montoye, Caspersen 1985; Caspersen 1989).

Logs are similar to diaries but provide a record of participation in specific types of physical activity rather than in all activities (King et al. 1991). The time that activity was started and stopped may be recorded, either soon after participation or at the end of the day. Logs can be useful for recording participation in an exercise training program. But as with diaries, they can be inconvenient for the participant, and their use may itself influence the participant's behavior.

Physical Activity and Health

Table 2-3. Assessment procedures and their potential use in epidemiologic research

Measurement tool	Applicable age groups	Use in large scale studies	Low \$ cost	Low time cost	Low subject time cost	Low subject effort cost	Likely to influence behavior	Acceptable to persons	Socially acceptable	Activity specific
Surveying										
Task specific diary	adult, elderly	yes	yes	yes	no	no	yes	?	yes	yes
Recall questionnaire	adult, elderly	yes	yes	yes	yes	yes	no	yes	yes	yes
Quantitative history	adult, elderly	yes	yes	no	no	no	no	yes	yes	yes
Global self-report	adult, elderly	yes	yes	yes	yes	yes	no	yes	yes	no
Monitoring										
Behavioral observation	adult, elderly	no	no	no	no	yes	yes	?	?	yes
Job classification	adult	yes	yes	yes	yes	yes	no	yes	yes	yes
Heart rate monitor	all	no	no	no	yes	yes	no	yes	yes	no
Heart rate and motion sensor	all	no	no	no	yes	yes	no	yes	yes	no
Electronic motion sensor	adult, elderly	yes	no	yes	yes	yes	no	yes	yes	no
Pedometer	adult, elderly	yes	yes	yes	yes	yes	no	yes	yes	no
Gait assessment	child, adult, elderly	no	no	yes	yes	yes	no	yes	yes	no
Accelerometers	all	yes	yes	yes	yes	yes	no	yes	yes	no
Horizontal time monitor	child, adult, elderly	no	no	yes	yes	yes	no	yes	yes	no
Stabilometers	infant	no	no	yes	yes	yes	no	yes	yes	no
Direct calorimetry	all	no	no	no	no	no	yes	no	no	yes
Indirect calorimetry	adult, elderly	no	no	no	no	no	yes	no	no	yes
Doubly labeled water	child, adult, elderly	yes	no	no	yes	yes	no	yes	yes	no

Modified from LaPorte, Montoye, Caspersen. *Public Health Reports*, 1985.

Note that most tests that are applicable for adults can be used in adolescents as well. Few tests can be applied to the pediatric age groups; among infants, only direct calorimetry, accelerometers, heart rate monitoring, and stabilometers can be used with accuracy.

Recall surveys are less likely to influence behavior and generally require less effort by the respondent than either diaries or logs, although some participants have trouble remembering details of past participation in physical activity (Baranowski 1985). Recall surveys of physical activity generally have been used for time frames of from 1 week to a lifetime (Kriska et al. 1988; Blair et al. 1991). They can ascertain either precise details about physical

activity or more general estimates of usual or typical participation. The recall survey is the method used for the national and state-based information systems providing data for Chapter 5 of this report.

The *retrospective quantitative history*—the most comprehensive form of physical activity recall survey—generally requires specific detail for time frames of up to 1 year (LaPorte, Montoye, Caspersen 1985). If the time frame is long enough, the quantitative history

Historical Background, Terminology, Evolution of Recommendations, and Measurement

can adequately represent year-round physical activity. For example, the Minnesota Leisure-Time Physical Activity Questionnaire and the Tecumseh questionnaire obtained information on the average frequency and duration of participation for a specific list of physical activities performed over the previous year (Montoye and Taylor 1984; Taylor et al. 1978). Unfortunately, obtaining this abundance of data is a heavy demand on the respondent's memory, and the complexity of the survey generates additional expense (LaPorte, Montoye, Caspersen 1985).

Global self-reports, another type of recall survey, ask individuals to rate their physical activity relative to other people's in general or to that of a similar age and sex group. This easy-to-use approach, which was employed for the National Health Interview Survey (NCHS, Bloom 1982), tends to best represent participation in vigorous physical activity (Washburn, Adams, Haile 1987; Caspersen and Pollard 1988; Jacobs et al. 1993). A weakness of this approach is that persons reporting the same rating may have different actual physical activity profiles (Washburn, Adams, Haile 1987; Caspersen and Pollard 1988).

Although survey approaches generally apply to adults, adolescents, and the elderly, survey instruments must often be tailored to the specific demographic requirements of the group under study. Recently, some researchers have suggested developing special survey instruments for older persons (Voorrips et al. 1991; Dipietro et al. 1993; Washburn et al. 1993) and adolescents or children (Noland et al. 1990; Sallis et al. 1993).

Measures Based on Direct Monitoring

The major alternative to surveys is to directly measure physical activity through behavioral observation, mechanical or electronic devices, or physiologic measurements (Table 2-3). Such approaches eliminate the problems of poor memory and biased self-reporting but are themselves limited by high cost and the burden on participants and staff. Consequently, these measures have been used primarily in small-scale studies, though they have been used recently in some large-scale studies (Lakka, Nyyssonen, Salonen 1994).

Behavioral observation is the straightforward process of watching and recording what a person does. Using general guidelines for caloric expenditure

associated with specific activities, a summary estimate of caloric output can be obtained from such observation. An important subtype of this approach is the classification of work based on the amount of physical activity it requires. These approaches can be labor-intensive (hence prohibitively expensive for large-scale studies) but are usually well accepted by study participants.

In the category of mechanical or electronic measurement, various instruments have been used to monitor heart rate and thus provide a continuous recording of a physiologic process that reflects both the duration and intensity of physical activity. Heart rate is typically used to estimate daily energy expenditure (i.e., oxygen uptake) on physical activity; the underlying assumption is that a linear relationship exists between heart rate and oxygen uptake. A major disadvantage of heart rate monitoring is the need to calibrate the heart rate–energy expenditure curve for each individual. Another limitation is that the relationship between heart rate and energy expenditure is variable for low-intensity physical activities. Most monitors have to be worn for extended periods by the participant, and they pose some discomfort and inconvenience.

Other approaches for using heart rate to measure physical activity include using the percentage of time spent during daily activities in various ranges of heart rate (Gilliam et al. 1981), using the difference between mean daily heart rate and resting heart rate (Sallis et al. 1990), and using the integration of the area under a heart rate versus time curve adjusted for resting heart rate (Freedson 1989). Heart rate alone may not be a suitable surrogate for determining the level of physical activity, given that other factors, such as psychological stress or changes in body temperature, can significantly influence heart rate throughout the day.

A variety of sensors have been developed to measure physical activity by detecting motion. Pedometers, perhaps the earliest motion sensors, were designed to count steps and thus measure the distance walked or run. However, not all pedometers are reliable enough for estimating physical activity in either laboratory or field research (Kashiwazaki et al. 1986; Washburn, Janney, Fenster 1990). Electronic motion sensors tend to perform better than their mechanical counterparts (Wong et al. 1981; Taylor et al. 1982; LaPorte et al. 1983). Their output has

Physical Activity and Health

been significantly correlated with energy expenditure assessed with indirect calorimetry in controlled laboratory conditions using graded treadmill exercise (Balogun, Amusa, Onyewadume 1988; Haskell et al. 1993; Montoye et al. 1996), under short-term controlled activity (e.g., walking or cycling over a measured course) for heart rate during laboratory and daily activities, and for observed behavior in a controlled setting (Klesges and Klesges 1987; Rogers et al. 1987; Freedson 1989; Sallis et al. 1990; Washburn, Janney, Fenster 1990). Direct validation has shown reasonable correlation with physical activity records completed over a year (Richardson et al. 1995). Recording simultaneously both the heart rate and the motion from sensors on several parts of the body and then calibrating each individual's heart rate and motion sensor output versus oxygen uptake for various activities can accurately estimate the energy expended from physical activity (Haskell et al. 1993). Several other devices (e.g., accelerometers, stabilometers) are of lesser value for large-scale studies, and their use is limited to small physiologic investigations.

Methods for physiologically monitoring energy expenditure include direct calorimetry (requiring the participant to remain in a metabolic chamber) and indirect calorimetry (requiring the participant to wear a mask and to carry equipment for analyzing expired air). Both methods are too expensive and complicated for use in large-scale studies. Another physiologic measurement, the use of doubly labeled water, offers researchers special opportunities to assess energy expenditure. By using two stable isotopes ($^2\text{H}_2\text{O}$ and H_2^{18}O) measured every few days or weeks in the urine, researchers can calculate the rate of carbon dioxide production—a reflection of the rate of energy production in humans over time. According to their body weight, study participants drink a specified amount of these isotopes. A mass spectrometer is used to track the amount of unmetabolized isotope in the urine. Although this technique obtains objective data with little effort on the part of participants, two disadvantages are its relatively high cost and its inability to distinguish between types of activities performed. The technique has been proven accurate when compared with indirect calorimetry (Klein et al. 1984; Westterterp et al. 1988; Edwards et al. 1990).

Measuring Intensity of Physical Activity

Common terms used to characterize the intensity of physical activity include light or low, moderate or mild, hard or vigorous, and very hard or strenuous (Table 2-4). A frequent approach to classifying intensity has been to express it relatively—that is, in relation to a person's capacity for a specific type of activity. For example, the intensity prescribed for aerobic exercise training usually is expressed in relation to the person's measured cardiorespiratory fitness (ACSM 1990). Because heart rate during aerobic exercise is highly associated with the increase in oxygen uptake, the percentage of maximal heart rate is often used as a surrogate for estimating the percentage of maximal oxygen uptake (ACSM 1990). Exercise intensity can also be expressed in absolute terms, such as a specific type of activity with an assigned intensity (for example, walking at 4 miles per hour or jogging at 6 miles per hour). Such quanta of work can also be described in absolute terms as METs, where one MET is about $3.5 \text{ ml O}_2 \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$, corresponding to the body at rest. The workloads in the just-quoted example are equivalent to 4 and 10 METs, respectively. The number of METs associated with a wide range of specific activities can be estimated from aggregated laboratory and field measurements (Ainsworth, Montoye, Leon 1994).

The process of aging illustrates an important relationship between absolute and specific measures. As people age, their maximal oxygen uptake decreases. Activity of a given MET value (an absolute intensity) therefore requires a greater percentage of their maximal oxygen uptake (a relative intensity). The aforementioned walk at 4 miles per hour (4 METs) may be light exercise for a 20-year-old, moderate for a 60-year-old, and vigorous for an 80-year-old.

Most exercise training studies have used relative intensity to evaluate specific exercise training regimens. On the other hand, observational studies relating physical activity to morbidity or mortality usually report absolute intensity or total amount of physical activity estimated from composite measures that include intensity, frequency, and duration. It is thus difficult to compare the intensity of activity that improves physiologic markers with the intensity of activity that may reduce morbidity and mortality.

Historical Background, Terminology, Evolution of Recommendations, and Measurement

Table 2-4. Classification of physical activity intensity, based on physical activity lasting up to 60 minutes

Intensity	Endurance-type activity								Strength-type exercise
	Relative intensity			Absolute intensity (METs) in healthy adults (age in years)					Relative intensity*
	$\dot{V}O_2$ max (%) heart rate reserve (%)	Maximal heart rate (%)	RPE†	Young (20–39)	Middle-aged (40–64)	Old (65–79)	Very old (80+)	RPE	Maximal voluntary contraction (%)
Very light	<25	<30	<9	<3.0	<2.5	<2.0	≤1.25	<10	<30
Light	25–44	30–49	9–10	3.0–4.7	2.5–4.4	2.0–3.5	1.26–2.2	10–11	30–49
Moderate	45–59	50–69	11–12	4.8–7.1	4.5–5.9	3.6–4.7	2.3–2.95	12–13	50–69
Hard	60–84	70–89	13–16	7.2–10.1	6.0–8.4	4.8–6.7	3.0–4.25	14–16	70–84
Very hard	≥85	≥90	>16	≥10.2	≥8.5	≥6.8	≥4.25	17–19	>85
Maximal‡	100	100	20	12.0	10.0	8.0	5.0	20	100

Table 2-4 provided courtesy of Haskell and Pollock.

*Based on 8–12 repetitions for persons under age 50 years and 10–15 repetitions for persons aged 50 years and older.

†Borg rating of Relative Perceived Exertion 6–20 scale (Borg 1982).

‡Maximal values are mean values achieved during maximal exercise by healthy adults. Absolute intensity (METs) values are approximate mean values for men. Mean values for women are approximately 1–2 METs lower than those for men.

Recent public health guidelines and research reports have used absolute intensity to define appropriate levels of physical activity, but the term “absolute” may convey a misplaced sense of precision. For example, the CDC-ACSM guidelines (Pate et al. 1995) use absolute intensity to classify brisk walking as moderate physical activity. In contrast, *Healthy People 2000* objective 1.3 defines brisk walking as “light to moderate” intensity and takes into account the age- and sex-related variability in maximal capacity (USDHHS 1990). One solution to this inconsistency in terminology is to create consistent categories that equate a variety of measures to the same adjective (Table 2-4). Using such a rubric, the observations of Spelman and colleagues (1993) that brisk walking for healthy adults aged 22–58 years demands 40–60 percent of their aerobic power suggests a correspondence with 3–5 METs and a classification of moderate intensity. Those prescribing an exercise pattern for adults can use the rating of perceived exertion (RPE) scale (ACSM 1991). An RPE of 10–11 corresponds to light intensity, 12–13 to moderate intensity, and 14–16 to hard intensity (Table 2-4), and the approximate

physiologic equivalents can be estimated. This type of subjective scale furnishes a convenient way to monitor performance.

Measuring Physical Fitness

Perhaps the most highly developed measurement area is the assessment of physical fitness, since it rests on physiologic measurements that have good to excellent accuracy and reliability. The major foci of fitness measurements are endurance (or cardiorespiratory fitness), muscular fitness, and body composition.

Endurance

Cardiorespiratory fitness, also referred to as cardiorespiratory capacity, aerobic power, or endurance fitness, is largely determined by habitual physical activity. However, other factors influence cardiorespiratory fitness, including age, sex, heredity, and medical status (Bouchard, Shepard, Stevens 1994).

The best criterion of cardiorespiratory fitness is maximal oxygen uptake or aerobic power ($\dot{V}O_2$ max). Measured in healthy persons during large muscle,

Physical Activity and Health

dynamic activity (e.g., walking, running, or cycling), $\dot{V}O_2$ max is primarily limited by the oxygen transport capacity of the cardiovascular system (Mitchell and Blomqvist 1971). $\dot{V}O_2$ max is most accurately determined by measuring expired air composition and respiratory volume during maximal exertion. This procedure requires relatively expensive equipment, highly trained technicians, and time and cooperation from the participant, all of which usually limit its use in large epidemiologic studies (Montoye et al. 1970; King et al. 1991).

Because the individual variation in mechanical and metabolic efficiency is for activities that do not require much skill—such as walking or running on a motor-driven treadmill, cycling on a stationary bicycle ergometer, or climbing steps—oxygen uptake can be quite accurately estimated from the rate of work (Siconolfi et al. 1982). Thus, $\dot{V}O_2$ max can be estimated from the peak exercise workload during a maximal exercise test without measuring respiratory gases. Such procedures require an accurately calibrated exercise device, careful adherence to a specific protocol, and good cooperation by the participant. They have been used in numerous exercise training studies for evaluating the effects of exercise on cardiovascular risk factors and performance, in secondary prevention trials for patients after hospitalization for myocardial infarction, and in some large-scale observational studies (Blair et al. 1989; Sidney et al. 1992).

Any maximal test to assess cardiorespiratory fitness imposes a burden on both the participant and the examiner. To reduce this burden, several submaximal exercise testing protocols have been developed. With these protocols, the heart rate response to a specified workload is used to predict the $\dot{V}O_2$ max. The underlying assumption (besides the linear relationship between heart rate and oxygen uptake) is that the participant's maximal heart rate can be estimated accurately. Both assumptions are adequately met when a standardized protocol is used to test a large sample of healthy adults. In some cases, no extrapolation to maximal values is performed, and an individual's cardiorespiratory fitness is expressed as the heart rate at a set workload (e.g., heart rate at 5 kilometers/hour or at 100 watts) or at the workload required to reach a specific submaximal heart rate (workload at a heart rate of 120 beats/minute).

In another approach to assessing cardiorespiratory fitness, participants usually walk, jog, or run a specified time or distance, and their performance is converted to an estimate of $\dot{V}O_2$ max (Cooper 1968). These procedures have been frequently used to test the cardiorespiratory fitness of children, of young adults, or of groups that have occupation-related physical fitness requirements, such as military and emergency service personnel. In many cases, these tests require maximal or near-maximal effort by the participant and thus have not been used for older persons or those at increased risk for CVD. The advantage is that large numbers of participants can be tested rapidly at low cost. However, to obtain an accurate evaluation, participants must be willing to exert themselves and know how to set a proper pace.

Muscular Fitness

Common measures of muscular fitness are muscular strength, muscular endurance, flexibility, and balance, agility, and coordination. Muscular strength can be measured during performance of either static or dynamic muscle contraction (NCHS, Wilmore 1989). Because muscular strength is specific to the muscle group, the testing of one group does not provide accurate information about the strength of other muscle groups (Clarke 1973). Thus, for a comprehensive assessment, strength testing must involve at least several major muscle groups, including the upper body, trunk, and lower body. Standard tests have included the bench press, leg extension, and biceps curl using free weights. The heaviest weight a person can lift only one time through the full range of motion for a particular muscle group is considered the person's maximum strength for that specific muscle group.

Muscular endurance is specific to each muscle group. Most tests for use in the general population do not distinguish between muscular endurance and muscular strength. Tests of muscular endurance and strength, which include sit-ups, push-ups, bent-arm hangs, and pull-ups, must be properly administered and may not discriminate well in some populations (e.g., pull-ups are not a good test for many populations because a high percentage of those tested will have 0 scores). Few laboratory tests of muscular endurance have been developed, and such tests usually involve having the participant perform a series of

Historical Background, Terminology, Evolution of Recommendations, and Measurement

contractions at a set percentage of maximal strength and at a constant rate until the person can no longer continue at that rate. The total work performed or the test duration is used as a measure of muscular endurance.

Flexibility is difficult to measure accurately and reliably. Because it is specific to the joint being tested, no one measure provides a satisfactory index of an individual's overall flexibility (Harris 1969). Field testing of flexibility frequently has been limited to the sit-and-reach test, which is considered to be a measure of lower back and hamstring flexibility. The criterion method for measuring flexibility in the laboratory is goniometry, which is used to measure the angle of the joint at both extremes in the range of motion (NCHS, Wilmore 1989).

Balance, agility, and coordination are especially important among older persons, who are more prone to fall and, as a result, suffer fractures due to reduced bone mineral density. Field methods for measuring balance, agility, and coordination have included various balance stands (e.g., one-foot stand with eyes open and with eyes closed; standing on a narrow block) and balance walks on a narrow line or rail (Tse and Bailey 1992). In the laboratory, computer-based technology is now being used to evaluate balance measured on an electronic force platform or to analyze a videotape recording of the participant walking (Lehmann et al. 1990). Agility or coordination are measured most frequently by using a field test, such as an agility walk or run (Cureton 1947). In the laboratory, coordination or reaction/movement time are determined by using electronic signaling and timing devices (Spirduso 1975). More development is needed to establish norms using standardized tests for measuring balance, agility, and coordination, especially of older persons.

Body Composition

In most population-based studies that have provided information on the relationship between physical activity and morbidity or mortality, body composition has been estimated by measuring body height and weight and calculating body mass index (weight/height²). The preferred method for determining amount of body fat and lean body mass in exercise training studies has been hydrostatic or underwater weighing (NCHS, Wilmore 1989); however, this

method lacks accuracy in some populations, including older persons and children (Lohman 1986). Anthropometric measurements (i.e., girths, diameters, and skinfolds) used to calculate the percentage of body fat have varying degrees of accuracy and reliability (Wilmore and Behnke 1970).

Data now suggest that the distribution of body fat, especially accumulation in the abdominal area, and total body fat are significant risk factors for CVD and diabetes (Bierman and Brunzell 1992; Blumberg and Alexander 1992). Researchers have determined the magnitude of this abdominal or central obesity by calculating the waist-to-hip circumference ratio or by using new electronic methods that can image regional fat tissue. New technologies that measure body composition include total body electrical conductivity (Segal et al. 1985), bioelectrical impedance (Lukaski et al. 1986), magnetic resonance imaging (Lohman 1984), and dual-energy x-ray absorptiometry (DEXA) (Mazess et al. 1990). These new procedures have substantial potential to provide new information on how changes in physical activity affect body composition and fat distribution.

Validity of Measurements

Health behaviors are difficult to measure, and this is certainly true for the behavior of physical activity. Of particular concern is how well self-reported physical activity accurately represents a person's habitual activity status. Factors that interfere with obtaining accurate assessments include incomplete recall, exaggeration of amount of activity, and nonrepresentative sampling of time intervals during which activity is assessed.

One of the principal difficulties in establishing the validity of a physical activity measure is the lack of a suitable "gold-standard" criterion measure for comparison. In the absence of a true criterion measure, cardiorespiratory fitness has often been used as a validation standard for physical activity surveys. Although habitual physical activity is a major determinant of cardiorespiratory fitness, other factors, such as genetic inheritance, also play a role. Therefore, a perfect correlation between physical activity reporting and cardiorespiratory fitness would not be expected. Nonetheless, correlations of reported physical activity with measured cardiorespiratory fitness have been examined. Table 2-5 shows results from studies

Physical Activity and Health

Table 2-5. Correlation of two survey instruments with physiologic measures of caloric exchange

Study	Sample	Physiologic test	Correlation coefficient
<i>Minnesota Leisure-Time Physical Activity Questionnaire</i>			
Taylor et al. (1978)	175 men	Treadmill endurance	0.45
Skinner et al. (1966)	54 men	Submaximal treadmill test	0.13 NS
Leon et al. (1981)	175 men	Treadmill	0.41
		Submaximal heart rate	0.59
DeBacker et al. (1981)	1,513 men	Submaximal treadmill test	0.10
Jacobs et al. (1993)	64 men	$\dot{V}O_2$ max	0.43
	& women	Submaximal heart rate	0.45
Richardson et al. (1995)	78 men & women	$\dot{V}O_2$ max	0.47
Albanes et al. (1990)	21 men	Resting caloric intake	0.17 NS
Montoye et al. (1996)	28 men	Doubly labeled water	0.26 NS
<i>College Alumni Study Survey</i>			
Siconolfi et al. (1985)	36 men	$\dot{V}O_2$ max	0.29
	32 women	$\dot{V}O_2$ max	0.46
Jacobs et al. (1993)	64 men	$\dot{V}O_2$ max	0.52
	& women	Submaximal heart rate	0.52
Albanes et al. (1990)	21 men	Resting caloric intake	0.32 NS
Montoye et al. (1996)	28 men	Doubly labeled water	0.39
		Energy intake, 7 days	0.44

NS = nonsignificant correlation coefficient; all others were statistically significant.

in which questionnaire data from the Minnesota Leisure-Time Physical Activity Questionnaire (Taylor et al. 1978) and the College Alumni Study survey (Paffenbarger et al. 1993) are compared with physiological measures, in most cases cardiorespiratory fitness. Although most correlation coefficients (e.g., Pearson's r) are statistically significant, they exhibit considerable variability (range 0.10 to 0.59), and the overall central tendency (median, 0.41) suggests only moderate external validity. However, in a study of predictors of cardiorespiratory fitness among adults (Blair et al. 1989), in all age and sex subgroups, self-reported physical activity was the principal contributor to the predictive models that also included weight, resting heart rate, and current smoking. Thus, self-reported physical activity may

not be perfectly correlated with cardiorespiratory fitness, but it may be the predominant predictive factor.

Because misclassification of physical activity, as could occur by using an invalid measure, would tend to bias studies towards finding no association, the consistently found associations between physical activity and lower risk of several diseases (as is discussed in Chapter 4) suggest that the measure has at least some validity. Moreover, they suggest that a more precise measure of physical activity would likely yield even stronger associations with health. Thus, although measurement of physical activity by currently available methods may be far from ideal, it has provided a means to investigate and demonstrate important health benefits of physical activity.

Chapter Summary

The assertion that frequent participation in physical activity contributes to better health has been a recurring theme in medicine and education throughout much of Western history. Early empirical observations and case studies suggesting that a sedentary life was not healthy have been supported by rigorous scientific investigation that has evolved over the past century. In recent decades, a number of experimental and clinical specialties have contributed substantially to an emerging field that may accurately be described as exercise science. This field includes disciplines ranging from exercise physiology and biomechanics to physical activity epidemiology, exercise psychology, clinical sports medicine, and preventive medicine. Research findings from these specialties provide the basis for this first Surgeon General's report on physical activity and health. Numerous expert panels, committees, and conferences have been convened over the years to evaluate the evidence relating physical activity and health. These gatherings have laid a solid foundation for the current consensus that for optimal health, people of all ages should be physically active on most days. Specific exercise recommendations have emphasized only vigorous activity for cardiorespiratory fitness until recently, when the benefits of moderate-intensity physical activity have been recognized and promoted as well.

Conclusions

1. Physical activity for better health and well-being has been an important theme throughout much of western history.
2. Public health recommendations have evolved from emphasizing vigorous activity for cardiorespiratory fitness to including the option of moderate levels of activity for numerous health benefits.
3. Recommendations from experts agree that for better health, physical activity should be performed regularly. The most recent recommendations advise people of all ages to include a minimum of 30 minutes of physical activity of moderate intensity (such as brisk walking) on most, if not all, days of the week. It is also acknowledged that for most people, greater health benefits can be obtained by engaging in physical activity of more vigorous intensity or of longer duration.
4. Experts advise previously sedentary people embarking on a physical activity program to start with short durations of moderate-intensity activity and gradually increase the duration or intensity until the goal is reached.
5. Experts advise consulting with a physician before beginning a new physical activity program for people with chronic diseases, such as CVD and diabetes mellitus, or for those who are at high risk for these diseases. Experts also advise men over age 40 and women over age 50 to consult a physician before they begin a vigorous activity program.
6. Recent recommendations from experts also suggest that cardiorespiratory endurance activity should be supplemented with strength-developing exercises at least twice per week for adults, in order to improve musculoskeletal health, maintain independence in performing the activities of daily life, and reduce the risk of falling.

Physical Activity and Health

Appendix A: *Healthy People 2000 Objectives*

The nation's public health goals for the 1990s and beyond, as presented in *Healthy People 2000* (USDHHS 1990), aim to increase the span of healthy life for all Americans, to reduce health disparities among Americans, and to achieve access to preventive services for all Americans. Reproduced here are the *Healthy People 2000* objectives for physical activity and fitness as revised in 1995 (USDHHS 1995).

Duplicate objectives that appear in two or more priority areas are marked with an asterisk alongside the objective number.

Physical Activity and Fitness

Health Status Objectives

- 1.1* Reduce coronary heart disease deaths to no more than 100 per 100,000 people.

Special Population Target

Coronary Deaths (per 100,000)

2000 Target

- 1.1a Blacks

115

- 1.2* Reduce overweight to a prevalence of no more than 20 percent among people aged 20 and older and no more than 15 percent among adolescents aged 12–19.

Special Population Target

Overweight Prevalence

2000 Target

- 1.2a Low-income women aged 20 and older

25%

- 1.2b Black women aged 20 and older

30%

- 1.2c Hispanic women aged 20 and older

25%

- 1.2d American Indians/Alaska Natives

30%

- 1.2e People with disabilities

25%

- 1.2f Women with high blood pressure

41%

- 1.2g Men with high blood pressure

35%

- 1.2h Mexican-American men

25%

Note: For people aged 20 and older, overweight is defined as body mass index (BMI) equal to or greater than 27.8 for men and 27.3 for women. For adolescents, overweight is defined as BMI equal to or greater than 23.0 for males aged 12–14, 24.3 for males aged 15–17, 25.8 for males aged 18–19, 23.4 for females aged 12–14, 24.8 for females aged 15–17, and 25.7 for females aged 18–19. The values for adults are the gender-specific 85th percentile values of the 1976–80 National Health and Nutrition Examination Survey (NHANES II), reference population 20–29 years of age. For adolescents, overweight was defined using BMI cutoffs based on modified age- and gender-specific 85th percentile values of the NHANES II. BMI is calculated by dividing weight in kilograms by the square of height in meters. The cut points used to define overweight approximate the 120 percent of desirable body weight definition used in the 1990 objectives.

Risk Reduction Objectives

- 1.3* Increase to at least 30 percent the proportion of people aged 6 and older who engage regularly, preferably daily, in light to moderate physical activity for at least 30 minutes per day.

Special Population Targets

Moderate Physical Activity

2000 Target

- 1.3a Hispanics aged 18 and older
5 or more times per week

25 %

Note: Light to moderate physical activity requires sustained, rhythmic muscular movements, is at least equivalent to sustained walking, and is performed at less than 60 percent of maximum heart rate for age. Maximum heart rate equals roughly 220 beats per minute minus age. Examples may include walking, swimming, cycling, dancing, gardening and yardwork, various domestic and occupational activities, and games and other childhood pursuits.

Historical Background, Terminology, Evolution of Recommendations, and Measurement

- 1.4 Increase to at least 20 percent the proportion of people aged 18 and older and to at least 75 percent the proportion of children and adolescents aged 6–17 who engage in vigorous physical activity that promotes the development and maintenance of cardiorespiratory fitness 3 or more days per week for 20 or more minutes per occasion.

Special Population Targets

Vigorous Physical Activity	2000 Target
1.4a Lower-income people aged 18 and older (annual family income <\$20,000)	12%
1.4b Blacks aged 18 years and older	17%
1.4c Hispanics aged 18 years and older	17%

Note: Vigorous physical activities are rhythmic, repetitive physical activities that use large muscle groups at 60 percent or more of maximum heart rate for age. An exercise rate of 60 percent of maximum heart rate for age is about 50 percent of maximal cardiorespiratory capacity and is sufficient for cardiorespiratory conditioning. Maximum heart rate equals roughly 220 beats per minute minus age.

- 1.5 Reduce to no more than 15 percent the proportion of people aged 6 and older who engage in no leisure-time physical activity.

Special Population Targets

No Leisure-Time Physical Activity	2000 Target
1.5a People aged 65 and older	22%
1.5b People with disabilities	20%
1.5c Lower-income people (annual family income <\$20,000)	17%
1.5d Blacks aged 18 and older	20%
1.5e Hispanics aged 18 and older	25%
1.5f American Indians/Alaska Natives aged 18 and older	21%

Note: For this objective, people with disabilities are people who report any limitation in activity due to chronic conditions.

- 1.6 Increase to at least 40 percent the proportion of people aged 6 and older who regularly perform physical activities that enhance and maintain muscular strength, muscular endurance, and flexibility.
- 1.7* Increase to at least 50 percent the proportion of overweight people aged 12 and older who have adopted sound dietary practices combined with regular physical activity to attain an appropriate body weight.

Special Population Targets

Adoption of Weight-Loss Practices	2000 Target
1.7a Overweight Hispanic males aged 18 and older	24%
1.7b Overweight Hispanic females aged 18 and older	22%

Services and Protection Objectives

- 1.8 Increase to at least 50 percent the proportion of children and adolescents in 1st–12th grade who participate in daily school physical education.
- 1.9 Increase to at least 50 percent the proportion of school physical education class time that students spend being physically active, preferably engaged in lifetime physical activities.

Physical Activity and Health

Note: Lifetime activities are activities that may be readily carried into adulthood because they generally need only one or two people. Examples include swimming, bicycling, jogging, and racquet sports. Also counted as lifetime activities are vigorous social activities such as dancing. Competitive group sports and activities typically played only by young children such as group games are excluded.

- 1.10 Increase the proportion of worksites offering employer-sponsored physical activity and fitness programs as follows:

Worksite Size	2000 Target
50–99 employees	20%
100–249 employees	35%
250–749 employees	50%
≥750 employees	80%

- 1.11 Increase community availability and accessibility of physical activity and fitness facilities as follows:

Facility	2000 Target
Hiking, biking, and fitness trail miles	1 per 10,000 people
Public swimming pools	1 per 25,000 people
Acres of park and recreation open space	4 per 1,000 people (250 people per managed acre)

- 1.12 Increase to at least 50 percent the proportion of primary care providers who routinely assess and counsel their patients regarding the frequency, duration, type, and intensity of each patient's physical activity practices.

Health Status Objective

- 1.13* Reduce to no more than 90 per 1,000 people the proportion of all people aged 65 and older who have difficulty in performing two or more personal care activities thereby preserving independence.

Special Population Targets

Difficulty Performing Self Care (per 1,000)	2000 Target
1.13a People aged 85 and older	325
1.13b Blacks aged 65 and older	98

Note: Personal care activities are bathing, dressing, using the toilet, getting in and out of bed or chair, and eating.

Appendix B: NIH Consensus Conference Statement

In Press (3/18/96)

National Institutes of Health
Consensus Development Conference Statement
Physical Activity and Cardiovascular Health
December 18–20, 1995

NIH Consensus Statements are prepared by a nonadvocate, non-Federal panel of experts, based on (1) presentations by investigators working in areas relevant to the consensus questions during a 2-day public session; (2) questions and statements from conference attendees during open discussion periods that are part of the public session; and (3) closed deliberations by the panel during the remainder of the second day and morning of the third. This statement is an independent report of the panel and is not a policy statement of the NIH or the Federal Government.

Abstract

Objective. To provide physicians and the general public with a responsible assessment of the relationship between physical activity and cardiovascular health.

Participants. A non-Federal, nonadvocate, 13-member panel representing the fields of cardiology, psychology, exercise physiology, nutrition, pediatrics, public health, and epidemiology. In addition, 27 experts in cardiology, psychology, epidemiology, exercise physiology, geriatrics, nutrition, pediatrics, public health, and sports medicine presented data to the panel and a conference audience of 600.

Evidence. The literature was searched through Medline and an extensive bibliography of references was provided to the panel and the conference audience. Experts prepared abstracts with relevant citations from the literature. Scientific evidence was given precedence over clinical anecdotal experience.

Consensus Process. The panel, answering pre-defined questions, developed their conclusions based on the scientific evidence presented in open forum and the scientific literature. The panel composed a draft statement that was read in its entirety and circulated to the experts and the audience for

comment. Thereafter, the panel resolved conflicting recommendations and released a revised statement at the end of the conference. The panel finalized the revisions within a few weeks after the conference.

Conclusions. All Americans should engage in regular physical activity at a level appropriate to their capacity, needs, and interest. Children and adults alike should set a goal of accumulating at least 30 minutes of moderate-intensity physical activity on most, and preferably, all days of the week. Most Americans have little or no physical activity in their daily lives, and accumulating evidence indicates that physical inactivity is a major risk factor for cardiovascular disease. However, moderate levels of physical activity confer significant health benefits. Even those who currently meet these daily standards may derive additional health and fitness benefits by becoming more physically active or including more vigorous activity. For those with known cardiovascular disease, cardiac rehabilitation programs that combine physical activity with reduction in other risk factors should be more widely used.

Introduction

Over the past 25 years, the United States has experienced a steady decline in the age-adjusted death toll from cardiovascular disease (CVD), primarily in mortality caused by coronary heart disease and stroke. Despite this decline, coronary heart disease remains the leading cause of death and stroke the third leading cause of death. Lifestyle improvements by the American public and better control of the risk factors for heart disease and stroke have been major factors in this decline.

Coronary heart disease and stroke have many causes. Modifiable risk factors include smoking, high blood pressure, blood lipid levels, obesity, diabetes, and physical inactivity. In contrast to the positive national trends observed with cigarette smoking, high blood pressure, and high blood cholesterol, obesity and physical inactivity in the United States have not improved. Indeed automation and other technologies have contributed greatly to lessening physical activity at work and home.

Physical Activity and Health

The purpose of this conference was to examine the accumulating evidence on the role of physical activity in the prevention and treatment of CVD and its risk factors.

Physical activity in this statement is defined as "bodily movement produced by skeletal muscles that requires energy expenditure" and produces healthy benefits. Exercise, a type of physical activity, is defined as "a planned, structured, and repetitive bodily movement done to improve or maintain one or more components of physical fitness." Physical inactivity denotes a level of activity less than that needed to maintain good health.

Physical inactivity characterizes most Americans. Exertion has been systematically engineered out of most occupations and lifestyles. In 1991, 54 percent of adults reported little or no regular leisure physical activity. Data from the 1990 Youth Risk Behavior Survey show that most teenagers in grades 9-12 are not performing regular vigorous activity. About 50 percent of high school students reported they are not enrolled in physical education classes.

Physical activity protects against the development of CVD and also favorably modifies other CVD risk factors, including high blood pressure, blood lipid levels, insulin resistance, and obesity. The type, frequency, and intensity of physical activity that are needed to accomplish these goals remain poorly defined and controversial.

Physical activity is also important in the treatment of patients with CVD or those who are at increased risk for developing CVD, including patients who have hypertension, stable angina, or peripheral vascular disease, or who have had a prior myocardial infarction or heart failure. Physical activity is an important component of cardiac rehabilitation, and people with CVD can benefit from participation. However, some questions remain regarding benefits, risks, and costs associated with becoming physically active.

Many factors influence adopting and maintaining a physically active lifestyle, such as socioeconomic status, cultural influences, age, and health status. Understanding is needed on how such variables influence the adoption of this behavior at the individual level. Intervention strategies for encouraging individuals from different backgrounds to adopt and adhere to a physically active lifestyle need to be

developed and tested. Different environments such as schools, worksites, health care settings, and the home can play a role in promoting physical activity. These community-level factors also need to be better understood.

To address these and related issues, the NIH's National Heart, Lung, and Blood Institute and Office of Medical Applications of Research convened a Consensus Development Conference on Physical Activity and Cardiovascular Health. The conference was cosponsored by the NIH's National Institute of Child Health and Human Development, National Institute on Aging, National Institute of Arthritis and Musculoskeletal and Skin Diseases, National Institute of Diabetes and Digestive and Kidney Diseases, National Institute of Nursing Research, Office of Research on Women's Health, and Office of Disease Prevention, as well as the Centers for Disease Control and Prevention and the President's Council on Physical Fitness and Sports.

The conference brought together specialists in medicine, exercise physiology, health behavior, epidemiology, nutrition, physical therapy, and nursing as well as representatives from the public. After a day and a half of presentations and audience discussion, an independent, non-Federal consensus panel weighed the scientific evidence and developed a draft statement that addressed the following five questions.

- What is the health burden of a sedentary lifestyle on the population?
- What type, what intensity, and what quantity of physical activity are important to prevent cardiovascular disease?
- What are the benefits and risks of different types of physical activity for people with cardiovascular disease?
- What are the successful approaches to adopting and maintaining a physically active lifestyle?
- What are the important questions for future research?

1. What Is the Health Burden of a Sedentary Lifestyle on the Population?

Physical inactivity among the U.S. population is now widespread. National surveillance programs have documented that about one in four adults (more

Historical Background, Terminology, Evolution of Recommendations, and Measurement

women than men) currently have sedentary lifestyles with no leisure time physical activity. An additional one-third of adults are insufficiently active to achieve health benefits. The prevalence of inactivity varies by gender, age, ethnicity, health status, and geographic region but is common to all demographic groups. Change in physical exertion associated with occupation has declined markedly in this century.

Girls become less active than do boys as they grow older. Children become far less active as they move through adolescence. Obesity is increasing among children, at least in part related to physical inactivity. Data indicate that obese children and adolescents have a high risk of becoming obese adults, and obesity in adulthood is related to coronary artery disease, hypertension, and diabetes. Thus, the prevention of childhood obesity has the potential of preventing CVD in adults. At age 12, 70 percent of children report participation in vigorous physical activity; by age 21 this activity falls to 42 percent for men and 30 percent for women. Furthermore, as adults age, their physical activity levels continue to decline.

Although knowledge about physical inactivity as a risk factor for CVD has come mainly from investigations of middle-aged, white men, more limited evidence from studies in women minority groups and the elderly suggests that the findings are similar in these groups. On the basis of current knowledge, we must note that physical inactivity occurs disproportionately among Americans who are not well educated and who are socially or economically disadvantaged.

Physical activity is directly related to physical fitness. Although the means of measuring physical activity have varied between studies (i.e., there is no standardization of measures), evidence indicates that physical inactivity and lack of physical fitness are directly associated with increased mortality from CVD. The increase in mortality is not entirely explained by the association with elevated blood pressure, smoking, and blood lipid levels.

There is an inverse relationship between measures of physical activity and indices of obesity in most U.S. population studies. Only a few studies have examined the relationship between physical activity and body fat distribution, and these suggest an inverse relationship between levels of physical activity and visceral fat. There is evidence that increased physical activity facilitates weight loss and

that the addition of physical activity to dietary energy restriction can increase and help to maintain loss of body weight and body fat mass.

Middle-aged and older men and women who engage in regular physical activity have significantly higher high-density lipoprotein (HDL) cholesterol levels than do those who are sedentary. When exercise training has extended to at least 12 weeks, beneficial HDL cholesterol level changes have been reported.

Most studies of endurance exercise training of individuals with normal blood pressure and those with hypertension have shown decreases in systolic and diastolic blood pressure. Insulin sensitivity is also improved with endurance exercise.

A number of factors that affect thrombotic function—including hematocrit, fibrinogen, platelet function, and fibrinolysis—are related to the risk of CVD. Regular endurance exercise lowers the risk related to these factors.

The burden of CVD rests most heavily on the least active. In addition to its powerful impact on the cardiovascular system, physical inactivity is also associated with other adverse health effects, including osteoporosis, diabetes, and some cancers.

2. What Type, What Intensity, and What Quantity of Physical Activity Are Important to Prevent Cardiovascular Disease?

Activity that reduces CVD risk factors and confers many other health benefits does not require a structured or vigorous exercise program. The majority of benefits of physical activity can be gained by performing moderate-intensity activities. The amount or type of physical activity needed for health benefits or optimal health is a concern due to limited time and competing activities for most Americans. The amount and types of physical activity that are needed to prevent disease and promote health must, therefore, be clearly communicated, and effective strategies must be developed to promote physical activity to the public.

The quantitative relationship between level of activity or fitness and magnitude of cardiovascular benefit may extend across the full range of activity. A moderate level of physical activity confers health benefits. However, physical activity must be performed regularly to maintain these effects.

Physical Activity and Health

Moderate-intensity activity performed by previously sedentary individuals results in significant improvement in many health-related outcomes. These moderate intensity activities are more likely to be continued than are high-intensity activities.

We recommend that all people in the United States increase their regular physical activity to a level appropriate to their capacities, needs, and interest. We recommend that all children and adults should set a long-term goal to accumulate at least 30 minutes or more of moderate-intensity physical activity on most, or preferably all, days of the week. Intermittent or shorter bouts of activity (at least 10 minutes), including occupational, nonoccupational, or tasks of daily living, also have similar cardiovascular and health benefits if performed at a level of moderate intensity (such as brisk walking, cycling, swimming, home repair, and yardwork) with an accumulated duration of at least 30 minutes per day. People who currently meet the recommended minimal standards may derive additional health and fitness benefits from becoming more physically active or including more vigorous activity.

Some evidence suggests lowered mortality with more vigorous activity, but further research is needed to more specifically define safe and effective levels. The most active individuals have lower cardiovascular morbidity and mortality rates than do those who are least active; however, much of the benefit appears to be accounted for by comparing the least active individuals to those who are moderately active. Further increases in the intensity or amount of activity produce further benefits in some, but not all, parameters of risk. High-intensity activity is also associated with an increased risk of injury, discontinuation of activity, or acute cardiac events during the activity. Current low rates of regular activity in Americans may be partially due to the mis-perception of many that vigorous, continuous exercise is necessary to reap health benefits. Many people, for example, fail to appreciate walking as "exercise" or to recognize the substantial benefits of short bouts (at least 10 minutes) of moderate-level activity.

The frequency, intensity, and duration of activity are interrelated. The number of episodes of activity recommended for health depends on the intensity and/or duration of the activity: higher

intensity or longer duration activity could be performed approximately three times weekly and achieve cardiovascular benefits, but low-intensity or shorter duration activities should be performed more often to achieve cardiovascular benefits.

The appropriate type of activity is best determined by the individual's preferences and what will be sustained. Exercise, or a structured program of activity, is a subset of activity that may encourage interest and allow for more vigorous activity. People who perform more formal exercise (i.e., structured or planned exercise programs) can accumulate this daily total through a variety of recreational or sports activities. People who are currently sedentary or minimally active should gradually build up to the recommended goal of 30 minutes of moderate activity daily by adding a few minutes each day until reaching their personal goal to reduce the risk associated with suddenly increasing the amount or intensity of exercise. (The defined levels of effort depend on individual characteristics such as baseline fitness and health status.)

Developing muscular strength and joint flexibility is also important for an overall activity program to improve one's ability to perform tasks and to reduce the potential for injury. Upper extremity and resistance (or strength) training can improve muscular function, and evidence suggests that there may be cardiovascular benefits, especially in older patients or those with underlying CVD, but further research and guidelines are needed. Older people or those who have been deconditioned from recent inactivity or illness may particularly benefit from resistance training due to improved ability in accomplishing tasks of daily living. Resistance training may contribute to better balance, coordination, and agility that may help prevent falls in the elderly.

Physical activity carries risks as well as benefits. The most common adverse effects of activity relate to musculoskeletal injury and are usually mild and self-limited. The risk of injury increases with increased intensity, frequency, and duration of activity and also depends on the type of activity. Exercise-related injuries can be reduced by moderating these parameters. A more serious but rare complication of activity is myocardial infarction or sudden cardiac death. Although persons who engage in vigorous physical

Historical Background, Terminology, Evolution of Recommendations, and Measurement

activity have a slight increase in risk of sudden cardiac death during activity, the health benefits outweigh this risk because of the large overall risk reduction.

In children and young adults, exertion-related deaths are uncommon and are generally related to congenital heart defects (e.g., hypertrophic cardiomyopathy, Marfan's syndrome, severe aortic valve stenosis, prolonged QT syndromes, cardiac conduction abnormalities) or to acquired myocarditis. It is recommended that patients with those conditions remain active but not participate in vigorous or competitive athletics.

Because the risks of physical activity are very low compared with the health benefits, most adults do not need medical consultation or pretesting before starting a moderate-intensity physical activity program. However, those with known CVD and men over age 40 and women over age 50 with multiple cardiovascular risk factors who contemplate a program of vigorous activity should have a medical evaluation prior to initiating such a program.

3. What Are the Benefits and Risks of Different Types of Physical Activity for People with Cardiovascular Disease?

More than 10 million Americans are afflicted with clinically significant CVD, including myocardial infarction, angina pectoris, peripheral vascular disease, and congestive heart failure. In addition, more than 300,000 patients per year are currently subjected to coronary artery bypass surgery and a similar number to percutaneous transluminal coronary angioplasty. Increased physical activity appears to benefit each of these groups. Benefits include reduction in cardiovascular mortality, reduction of symptoms, improvement in exercise tolerance and functional capacity, and improvement in psychological well-being and quality of life.

Several studies have shown that exercise training programs significantly reduce overall mortality, as well as death caused by myocardial infarction. The reported reductions in mortality have been highest—approximately 25 percent—in cardiac rehabilitation programs that have included control of other cardiovascular risk factors. Rehabilitation programs using both moderate and vigorous physical activity have

been associated with reductions in fatal cardiac events, although the minimal or optimal level and duration of exercise required to achieve beneficial effects remains uncertain. Data are inadequate to determine whether stroke incidence is affected by physical activity or exercise training.

The risk of death during medically supervised cardiac exercise training programs is very low. However, those who exercise infrequently and have poor functional capacity at baseline may be at somewhat higher risk during exercise training. All patients with CVD should have a medical evaluation prior to participation in a vigorous exercise program.

Appropriately prescribed and conducted exercise training programs improve exercise tolerance and physical fitness in patients with coronary heart disease. Moderate as well as vigorous exercise training regimens are of value. Patients with low basal levels of exercise capacity experience the most functional benefits, even at relatively modest levels of physical activity. Patients with angina pectoris typically experience improvement in angina in association with a reduction in effort-induced myocardial ischemia, presumably as a result of decreased myocardial oxygen demand and increased work capacity.

Patients with congestive heart failure also appear to show improvement in symptoms, exercise capacity, and functional well-being in response to exercise training, even though left ventricular systolic function appears to be unaffected. The exercise program should be tailored to the needs of these patients and supervised closely in view of the marked predisposition of these patients to ischemic events and arrhythmias.

Cardiac rehabilitation exercise training often improves skeletal muscle strength and oxidative capacity and, when combined with appropriate nutritional changes, may result in weight loss. In addition, such training generally results in improvement in measures of psychological status, social adjustment, and functional capacity. However, cardiac rehabilitation exercise training has less influence on rates of return to work than many nonexercise variables, including employer attitudes, prior employment status, and economic incentives. Multifactorial intervention programs, including nutritional changes and medication plus exercise, are needed to improve health status and reduce cardiovascular disease risk.

Physical Activity and Health

Cardiac rehabilitation programs have traditionally been institutional-based and group-centered (e.g., hospitals, clinics, community centers). Referral and enrollment rates have been relatively low, generally ranging from 10 to 25 percent of patients with CHD. Referral rates are lower for women than for men and lower for non-whites than for whites. Home-based programs have the potential to provide rehabilitative services to a wider population. Home-based programs incorporating limited hospital visits with regular mail or telephone followup by a nurse case manager have demonstrated significant increases in functional capacity, smoking cessation, and improvement in blood lipid levels. A range of options exists in cardiac rehabilitation including site, number of visits, monitoring, and other services.

There are clear medical and economic reasons for carrying out cardiac rehabilitation programs. Optimal outcomes are achieved when exercise training is combined with educational messages and feedback about changing lifestyle. Patients who participate in cardiac rehabilitation programs show a lower incidence of rehospitalization and lower charges per hospitalization. Cardiac rehabilitation is a cost-efficient therapeutic modality that should be used more frequently.

4. What Are the Successful Approaches to Adopting and Maintaining a Physically Active Lifestyle?

The cardiovascular benefits from and physiological reactions to physical activity appear to be similar among diverse population subgroups defined by age, sex, income, region of residence, ethnic background, and health status. However, the behavioral and attitudinal factors that influence the motivation for and ability to sustain physical activity are strongly determined by social experiences, cultural background, and physical disability and health status. For example, perceptions of appropriate physical activity differ by gender, age, weight, marital status, family roles and responsibilities, disability, and social class. Thus, the following general guidelines will need to be further refined when one is planning with or prescribing for specific individuals and population groups, but generally physical activity is more likely to be initiated and maintained if the individual

- Perceives a net benefit.
- Chooses an enjoyable activity.
- Feels competent doing the activity.
- Feels safe doing the activity.
- Can easily access the activity on a regular basis.
- Can fit the activity into the daily schedule.
- Feels that the activity does not generate financial or social costs that he or she is unwilling to bear.
- Experiences a minimum of negative consequences such as injury, loss of time, negative peer pressure, and problems with self-identity.
- Is able to successfully address issues of competing time demands.
- Recognizes the need to balance the use of labor-saving devices (e.g., power lawn mowers, golf carts, automobiles) and sedentary activities (e.g., watching television, use of computers) with activities that involve a higher level of physical exertion.

Other people in the individual's social environment can influence the adoption and maintenance of physical activity. Health care providers have a key role in promoting smoking cessation and other risk-reduction behaviors. Preliminary evidence suggests that this also applies to physical activity. It is highly probable that people will be more likely to increase their physical activity if their health care provider counsels them to do so. Providers can do this effectively by learning to recognize stages of behavior change, to communicate the need for increased activity, to assist the patient in initiating activity, and by following up appropriately.

Family and friends can also be important sources of support for behavior change. For example, spouses or friends can serve as "buddies," joining in the physical activity; or a spouse could offer to take on a household task, giving his or her mate time to engage in physical activity. Parents can support their children's activity by providing transportation, praise, and encouragement, and by participating in activities with their children.

Worksites have the potential to encourage increased physical activity by offering opportunities, reminders, and rewards for doing so. For example, an appropriate indoor area can be set aside to enable walking during lunch hours. Signs placed near

Historical Background, Terminology, Evolution of Recommendations, and Measurement

elevators can encourage the use of the stairs instead. Discounts on parking fees can be offered to employees who elect to park in remote lots and walk.

Schools are a major community resource for increasing physical activity, particularly given the urgent need to develop strategies that affect children and adolescents. As noted previously, there is now clear evidence that U.S. children and adolescents have become more obese. There is also evidence that obese children and adolescents exercise less than their leaner peers. All schools should provide opportunities for physical activities that

- Are appropriate and enjoyable for children of all skill levels and are not limited to competitive sports or physical education classes.
- Appeal to girls as well as to boys, and to children from diverse backgrounds.
- Can serve as a foundation for activities throughout life.
- Are offered on a daily basis.

Successful approaches may involve mass education strategies or changes in institutional policies or community variables. In some environments (e.g., schools, worksites, community centers), policy-level interventions may be necessary to enable people to achieve and maintain an adequate level of activity. Policy changes that increase opportunities for physical activity can facilitate activity maintenance for motivated individuals and increase readiness to change among the less motivated. As in other areas of health promotion, mass communication strategies should be used to promote physical activity. These strategies should include a variety of mainstream channels and techniques to reach diverse audiences that acquire information through different media (e.g., TV, newspaper, radio, Internet).

5. What Are the Important Considerations for Future Research?

While much has been learned about the role of physical activity in cardiovascular health, there are many unanswered questions.

- Maintain surveillance of physical activity levels in the U.S. population by age, sex, geographic, and socioeconomic measures.

- Develop better methods for analysis and quantification of activity. These methods should be applicable to both work and leisure time measurements and provide direct quantitative estimates of activity.
- Conduct physiologic, biochemical, and genetic research necessary to define the mechanisms by which activity affects CVD including changes in metabolism as well as cardiac and vascular effects. This will provide new insights into cardiovascular biology that may have broader implications than for other clinical outcomes.
- Examine the effects of physical activity and cardiac rehabilitation programs on morbidity and mortality in elderly individuals.
- Conduct research on the social and psychological factors that influence adoption of a more active lifestyle and the maintenance of that behavior change throughout life.
- Carry out controlled randomized clinical trials among children and adolescents to test the effects of increased physical activity on CVD risk factor levels including obesity. The effects of intensity, frequency, and duration of increased physical activity should be examined in such studies.

Conclusions

Accumulating scientific evidence indicates that physical inactivity is a major risk factor for CVD. Moderate levels of regular physical activity confer significant health benefits. Unfortunately, most Americans have little or no physical activity in their daily lives.

All Americans should engage in regular physical activity at a level appropriate to their capacities, needs, and interests. All children and adults should set and reach a goal of accumulating at least 30 minutes of moderate-intensity physical activity on most, and preferably all, days of the week. Those who currently meet these standards may derive additional health and fitness benefits by becoming more physically active or including more vigorous activity.

Cardiac rehabilitation programs that combine physical activity with reduction in other risk factors should be more widely applied to those with known CVD. Well-designed rehabilitation programs have

Physical Activity and Health

benefits that are lost because of these programs' limited use.

Individuals with CVD and men over 40 or women over 50 years of age with multiple cardiovascular risk factors should have a medical evaluation prior to embarking on a vigorous exercise program.

Recognizing the importance of individual and societal factors in initiating and sustaining regular physical activity, the panel recommends the following:

- Development of programs for health care providers to communicate to patients the importance of regular physical activity.
- Community support of regular physical activity with environmental and policy changes at schools, worksites, community centers, and other sites.
- Initiation of a coordinated national campaign involving a consortium of collaborating health organizations to encourage regular physical activity.
- The implementation of the recommendations in this statement has considerable potential to improve the health and well-being of American citizens.

About the NIH Consensus Development Program

NIH Consensus Development Conferences are convened to evaluate available scientific information and resolve safety and efficacy issues related to a biomedical technology. The resultant NIH Consensus Statements are intended to advance understanding of the technology or issue in question and to be useful to health professionals and the public.

Historical Background, Terminology, Evolution of Recommendations, and Measurement

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Physical Activity and Health

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